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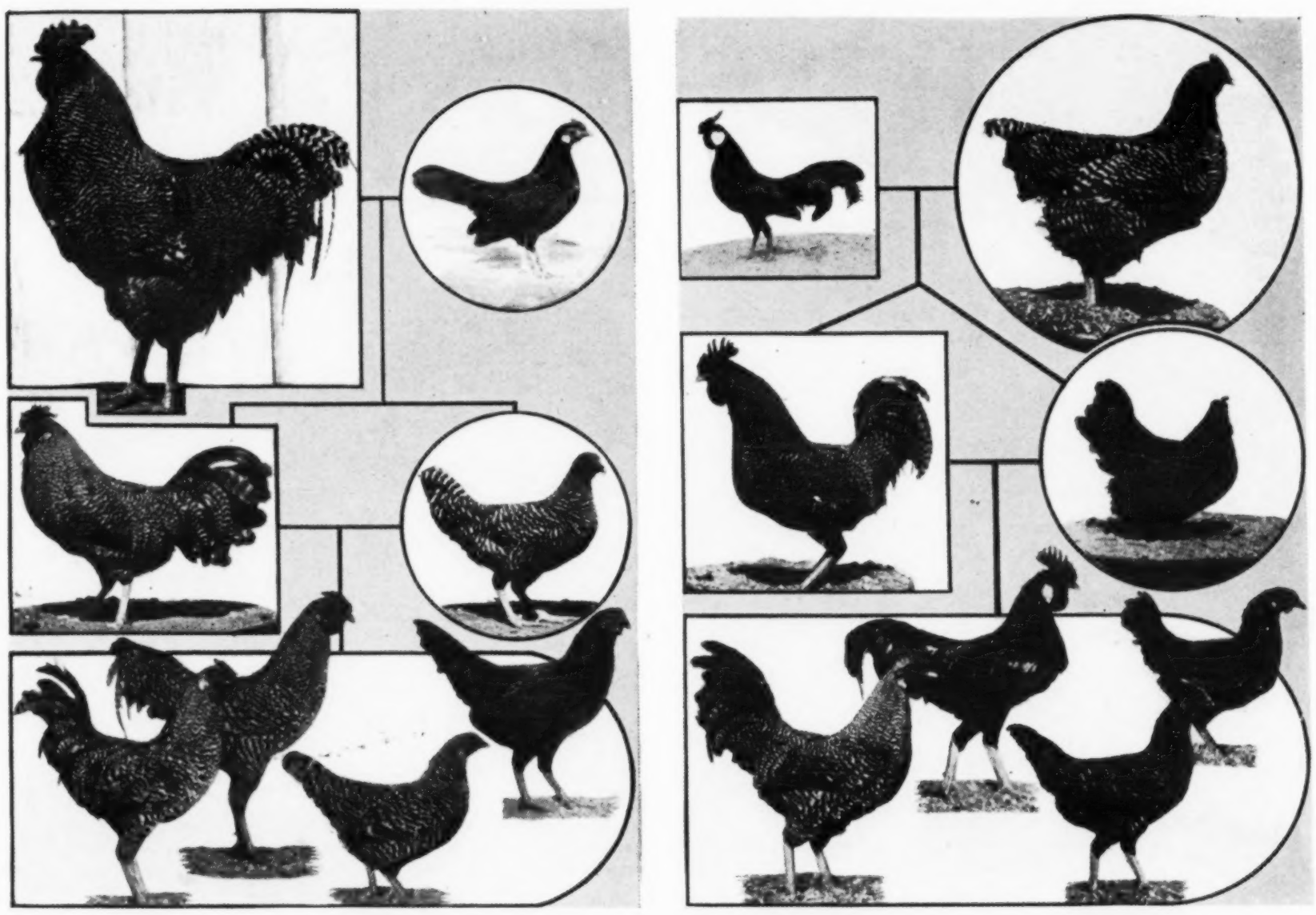

BODY-WEIGHT INHERITANCE IN THE FOWL

(See Page 283)

Anthropology and Eugenics

The Origin of Hooded Barley

A Re-Mutation in the Mouse

VOLUME 22 SEPTEMBER, 1931 NUMBER 9

The American Genetic Association

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AWNED AND HOODED BARLEY

Frontispiece

Awned (Winter Club), Hooded (Nepal). and a hybrid showing weak awns born on second flowering glumes of the hood. The Hooded form is very attractive to those who handle barley because the stiff barbed awns are a serious annoyance, and even a danger. Nevertheless the hooded varieties are so unproductive that they never stay long in favor. The change from the stiff barbed awn to the soft, much more leaf-like, hood is a striking one. Where and when it originally occurred is not certainly known, but a recent mutation has bridged the gap in a single "jump."

THE ORIGIN OF HOODED BARLEY

HARRY V. HARLAN

Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, Washington, D. C.

THERE must have been varied and prolonged Himalayan whoops of delight when some lucky Nepal farmer found the first hooded barley. For some thousands of years barley harvesters had searched more or less clothes for stray irritating awns, and doubtless the vows were many to grow "anything else but," another year. Then this new thing appeared, quite different from any barley seen heretofore. The long, harsh, stiff awn, with its edging of countless needle-like teeth, was replaced by a three-pronged appendage at the tip of the grain. Not only was the awn gone, but the new structure was not at all harsh, being more leaf-like in texture than the awn. The gods of gossip and sex in the village market must have been dethroned for at least a day, and many a flea surely had a chance to find new pastures in the crowds that debated over the novel exhibit, for primitive mountain farmers are observant, at least until the advent of schools.

Yet, the story of the hooded barleys is not so complete as we would like to have it. Such early references as we have been able to find, all trace back to a barley which was found in Nepal apparently between 1830 and 1837. At that time extensive collections were being accumulated at Saharumpore. It appears that at least two collectors, Dr. Wallich and Dr. Hamilton, travelled in Nepal between 1810 and 1840 collecting for the Botanical Garden at this place. Anyhow, it was about this time that someone found Nepal farmers cultivating this variety. Botanists over the world immediately scrambled into print to give it a name. Only a few succeeded in being the first to do so. The Botanical Garden of Saharumpore was under the direction of J. F. Royle, and in his treatise on the botany and animal life of the Himalaya Mountains in 1839 he gives a drawing of a hooded barley under the name of *Hordeum aegiceras*. Schlechtendahl, in 1837, had already described this barley in Linnaeus as *Hordeum trifurcatum*. This description undoubtedly was made from specimens sent to Europe from Saharumpore. In the next few years numerous references appeared in botanical literature. There were also frequent notes in the agricultural press where it was known as Nepal. The date of the introduction of this barley into America is not known. It probably was introduced quite soon after it reached Europe. It is mentioned by name in the *Genesee Farmer* of 1844, but we have found no complete description given until 1855, when the editor of the *Country Gentleman* comments on a sample supplied by I. W. Briggs, W. Macedon, N. Y. Briggs attributes its origin to Hindustan and the editor identifies it from the description in *Lowe's Practical Agriculture*. The first farm reports in this country were quite favorable even as they now are with farmers who try it for the first time. Within two or three years, however, the growers began to express dissatisfaction. One such expression occurs in the *Cultivator* of 1862 in which a correspondent who signs himself J. L. R. advertises seed for sale. He is apparently among the first to be afflicated by the "truth in advertising" complex. He says: "I have grown it 2 years and want to go back to the old varieties. One great objection I have to raising it is, that it thrashes so hard. A machine might separate it from the straw, but it can't

be done by the flail—at least that was the case with mine. The heads break very easily from the straw, and the kernel is so completely enveloped in the chaff that it is necessary to literally chop the heads fine to get the grain out. I can see no object in raising this grain, unless one is overrun with rats and mice, in which case—if this is his only crop of grain—he will be likely to starve them out. They would either have to emigrate or die —for they could not shell it fast enough to keep themselves alive."

The novelty of hoods has always proved very attractive to farmers. Hooded sorts are still carried by all seedsmen although even now we have no hooded varieties that are equal to the awned sorts in production, despite the long and frequent use of hooded parents in hybrid combinations.

All Varieties from a Single Origin

It is difficult to surmise whether all of the hooded barleys of the world have come from the original sport in Nepal or not. While we are not certain that the barley of that name originated in Nepal, it was found there. It must have originated there or near by and probably within a reasonable time prior to its discovery for it had reached neither western Asia nor Japan. In the latter country it certainly would have been of interest to plant growers. The Japanese have always shown great interest in unusual plants. We do not know enough about the western fringe of China to be able to say what types are found there. Hooded barleys, however, have been found in numbers north and west of China proper. The ones I have seen appear to be very similar to segregates which we have isolated from Nepal crosses. Barleys indistinguishable from the Nepal have been received from China recently but their history is as yet not clear. Even though a Nepal type should be found in western China, the information would add little that might be used in unravelling the story of this barley. The hoods are obviously a direct mutation. Such a mutation would need to occur but once. Native agricultural people exchange seed and plants with a facility that is surprising. Moreover, Nepal was once a vassal state of China and even up until the time of the overthrow of the Chinese Empire, tribute was sent overland from Nepal to Pekin. A dissemination of this striking plant along the route travelled would be less surprising than its absence.

Structure of the Hood

The exact nature of the hood is difficult to determine. The tissues altered are probably modified leaf tissues. The alternation is in the direction of sexual modifications. The central one of the three projections is a flower. This flower often bears stamens with fertile pollen. The two lateral projections are quite leaf-like in character and possibly represent outer glumes. The aberrant floret may project upward, outward or even downward from the tip of the lemma. The tissues immediately beyond the tip of the lemma in the varieties with sessile hoods are reversed. The small spines or teeth which occur on the lemmas and awns of barleys reveal the arrangement of tissues. In awned varieties of barley the teeth which occur on the "nerves" of the lemmas and on the awns point upwards in the direction of growth. In the hooded sorts, such as Nepal, the spines on the nerves of the lemmas point upward as in all other barleys. The teeth on the central nerve of the hood, however, reverse their direction at the point where the hood is attached, whether this be the tip of the lemma or a point on the awn where the flower originates. At the base of the hood which is hanging free, there is a cup-like cavity, in which more or less perfect floral organs are developed. As the tissue of the hood turns to form the cavity the teeth are again reversed. The tissue beyond the base of the cavity constitutes a normal floral glume. This glume sometimes terminates in a thin awn of some length and may represent a third lemma rather

than a palet, although it is smaller than the opposite glume.

As has been indicated, hoods, in hybrid populations, are of great interest. In some cases enormous pockets are developed. Again, the hood dwindles to a mere trace. In the heterozygous condition involving a strong-awned parent, combined with a weak-hooded one, the hood is often represented by a tiny depression on the dorsal surface of the awn and a corresponding protruberance on the ventral side. This is accompanied by a disturbance of the venation of the awn in which the veins are for a short distance diverted from straight lines. Otherwise the awns are of full length and width, and normal in structure.

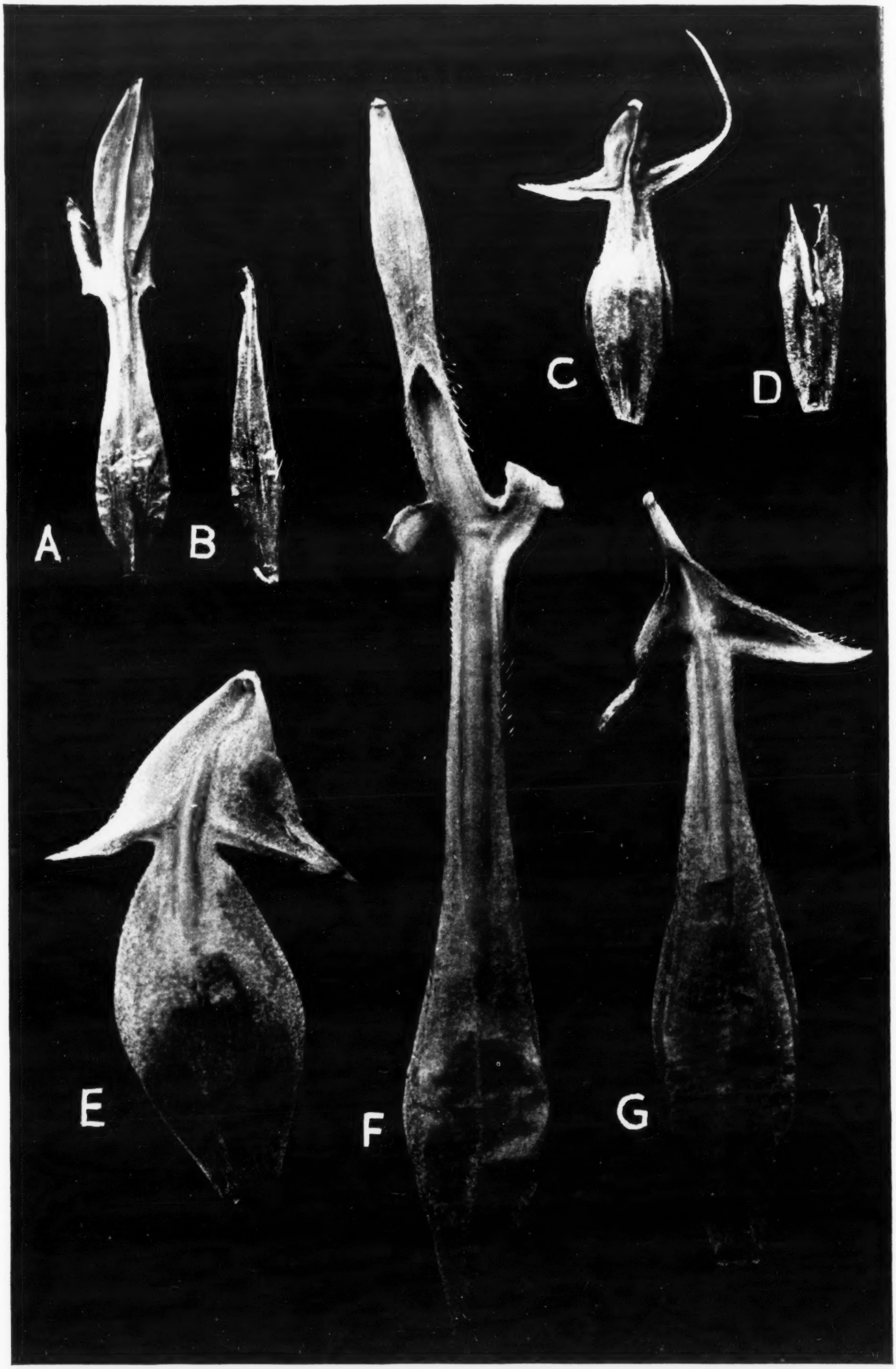
The hoods of Nepal are sessile. In hybrids they are often elevated on a short awn. Sometimes this awn may be one-third or even one-half the length of a normal one. Usually the longer the supporting awn, the smaller the hood. In the production of hooded varieties by hybridization, difficulty is experienced in securing fully sessile strains. This difficulty varies with the parents. Hybrids involving barleys of the Manchuria group produce many strains with sessile hoods. Those in which varieties of the Coast group are used as the non-hooded parent, seldom produce segregates that are fully sessile. In some crosses strains occur in which the hoods are attached at a point below the normal tip of the lemma. This results in a cleft which exposes the tip of the kernel. There are also variations in which more than one extra floral center develops. In hybrids awns are often found showing two successive centers of floral stimulus. (See Figures 2 and 3.)

The hoods are not always confined to the lemmas and the awns. Some-

HOODS ON OUTER GLUMES

Figure 1

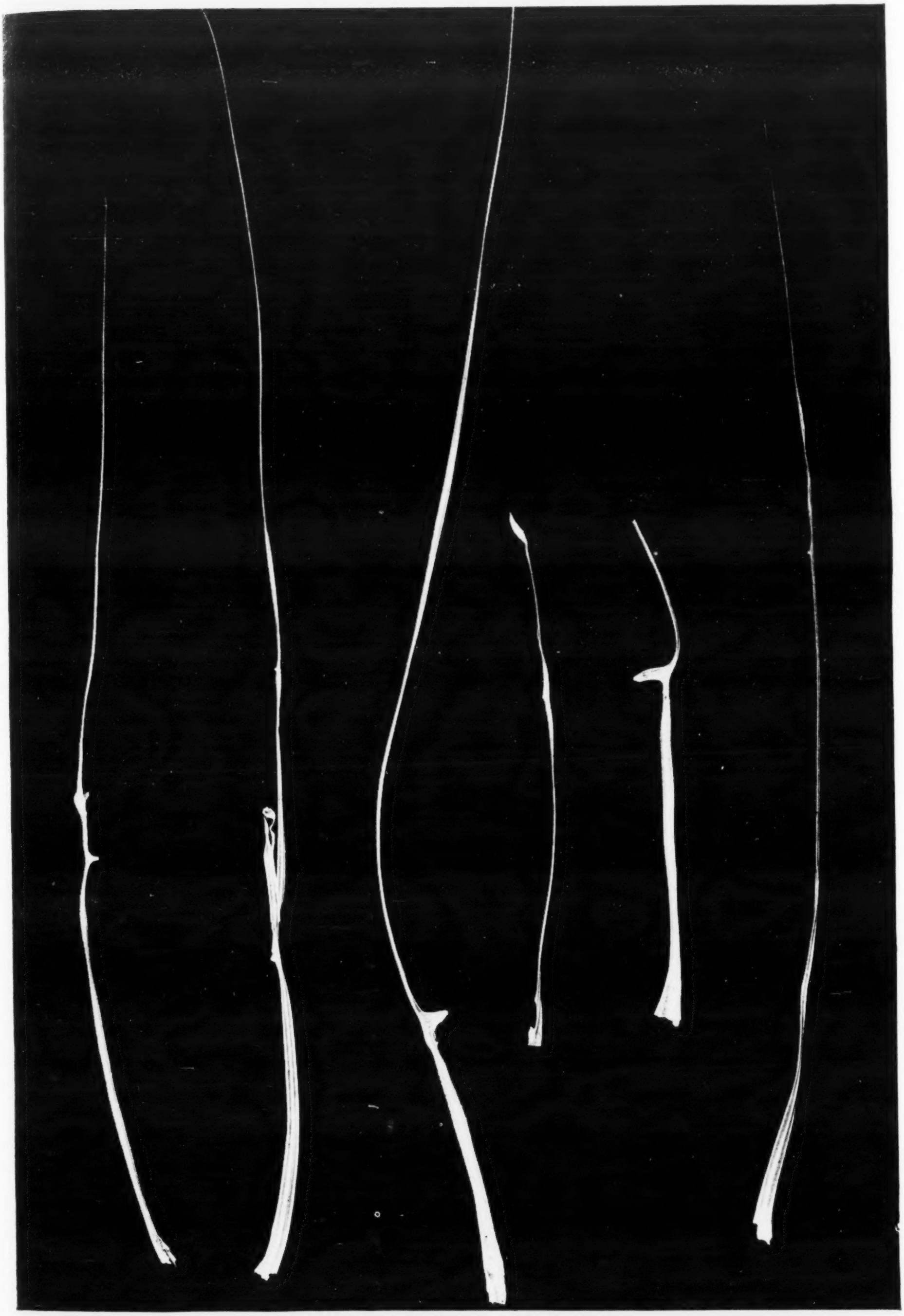
Above are shown outer glumes bearing hoods; below, enlargements of two of them. Hoods in such an unusual position are occasionally found in hybrid progenies. The existence of hoods on the outer glumes opens up interesting speculations on the homologous relation of outer glumes and lemmas.



VARIATION IN HOODS

Figure 2

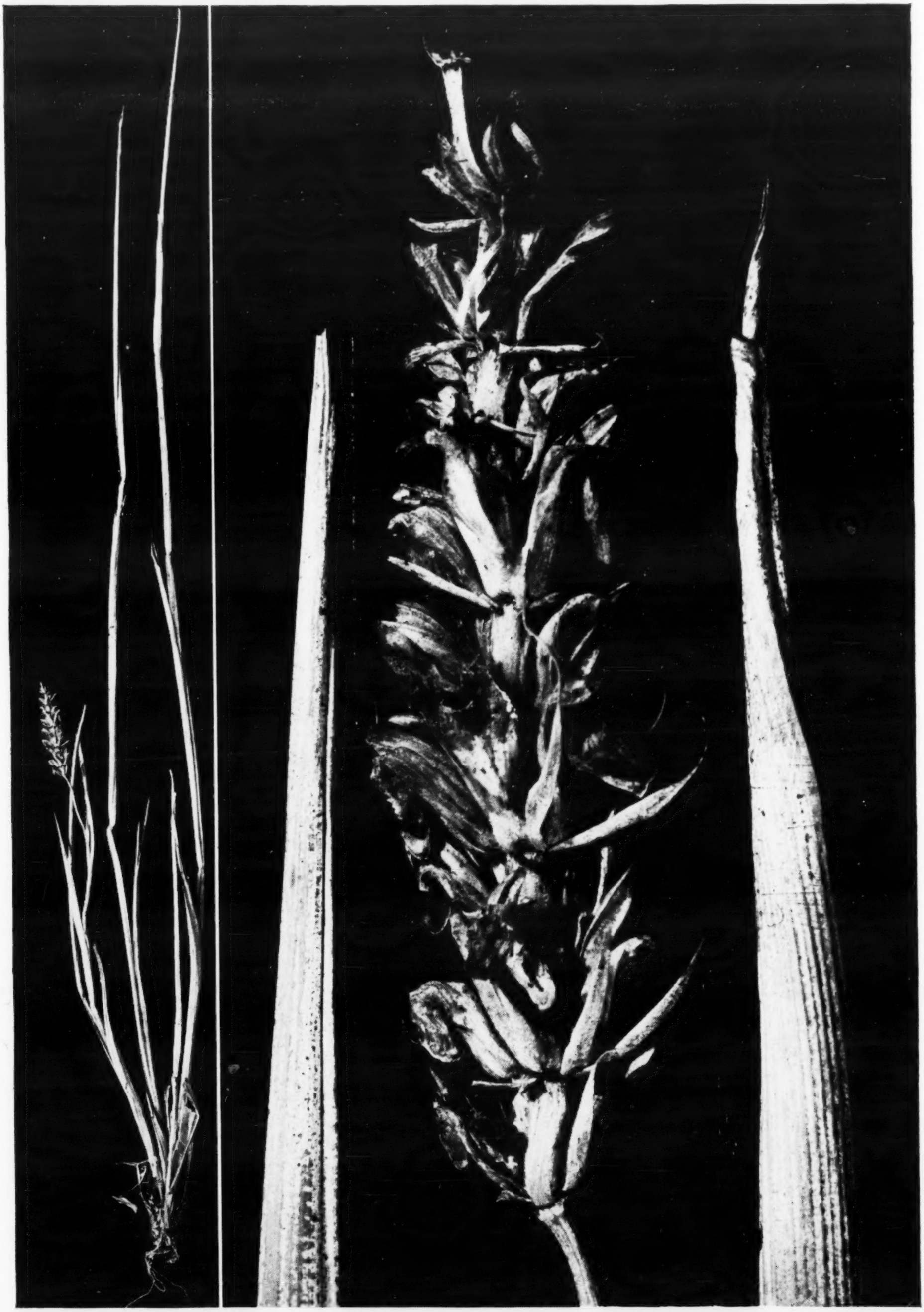
A, hood of normal Nepal; *B*, hood on (awnless × Nepal) segregate; *C*, large hood; *D*, subsessile hood; *E-G*, unusual hood forms, showing reversal of direction of teeth. This suggests that the hood represents two flowers attached end-to-end.



TRACES OF HOODS ON AWNS

Figure 3

Awns of plants heterozygous for hoods, showing vestigial hoods, some of them very small as on the awn at the right. Note also the repea.ed stimulus to hood-formation on some of the awns.



MUTANT PLANT WITH HOODED INFLORESCENCE

Figure 4

At left is shown the entire plant and at right the tips of the two sterile culms and a natural-size view of the head. This plant was a hybrid between an awned variety from Nepal, with Manchuria, another awned variety. The plant was sterile, so it could not be tested further. It is significant in throwing light on the origin of hooded barley that this mutant appeared in a form that came from near the place of origin of the hooded forms.

times, in hybrid progenies, hoods are found on the outer glumes. These are naturally quite small as nutrition is limited. The occurrence of hoods on the glumes leads one into speculation regarding the analogy between these organs and the lemmas, and into the general field of homologous tissues. (See Figure 1.)

The writer is not attempting to make a news item out of tissue origins that were known before he was born. However, there are certain relationships evident in barley which are worth noting and there are occasional abnormal developments which, while not bearing directly on the question of hoods, do show variation which, in its fluctuations, might include hoods.

Awns and Stygmas Homologous?

The vegetative part of a barley plant is very simple. It consists essentially of a jointed culm bearing alternate leaves. Inclosed in the base of each leaf sheath is a bud. Floral organs are modified vegetative parts and in barley there is not much to modify. The nature of the modification is most apparent when it is incomplete. In 1918 a plant was found at Aberdeen, Idaho, which showed a whole series of half-modified leaves at each node of the rachis* Sometimes a flower was enclosed; sometimes the vegetative stimulus overcame the floral one and a new branch arose. While flowers are themselves modified branches, it is modified leaves that constitute almost the whole of the floral structure. The ovary wall, for instance, is green because of the leaf chlorophyll layer which it contains. The writer has felt for some years that the barbs on the awns and the hairs on the stigma arise from the same basic tissue. If the awn and the stigma branch are homologous tissues their correlation is morphological. In 1915 a high positive correlation was found between the number of teeth on the awns and the number of hairs on the stigmas of smooth-awned barleys. The awns of most barleys are heavily toothed and the stigma branches covered with abundant hairs. In the fully smooth-awned barleys the stigma branches are almost free from hairs. In hybrid progenies all degrees of smoothness of the awns and hairiness of the stigma are found. These variations are hard to classify due to the difficulty of counting either teeth or hairs, but they are obviously correlated.

Whether or not these facts have any significance here is an open question. It does seem certain that the hoods came about by modification of leaf tissue. Where modified, the changes were such as to make the new cells comparable with those of the rachis nodes which produce buds. This is shown not only by the formation of stamens and fairly well-developed ovaries, but also by the profound effect seen in tissues adjacent to the disturbance.

A Hooded Mutation

Supposing that this erratic stimulus occurred but once and that in the mountains of Nepal, in what barley did it occur? We have recently come upon a little evidence. Among the 28 varieties used in the making of the Composite Cross†, there was one from the high Himalayas of Nepal called Everest. This variety, like trifurcatum, is naked but—it is awned. In one of the F_2 hybrid populations of Everest × Manchuria, a mutation was discovered. This plant was nearly leafless, the leaf blades on the upper nodes being reduced to mere spurs. The peduncle never elongated and the two uppermost leaves did not unroll. The two stalks thus culminated in conical

*See "Many-noded Dwarf Barley," Harry V. Harlan and Merritt N. Pope, Office of Cereal Investigations, U. S. Department of Agriculture, Washington, D. C. *Jour. Hered.*, Vol. XIII, No. 6; Wash., D. C., June, 1922.

†"A Composite Hybrid Mixture," Harry V. Harlan and Mary L. Martini, Principal Agronomist in Charge, Barley Investigations, and Assistant Botanist, Barley Investigations, respectively, Office of Cereal Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture. *Jour. Am. Soc. Agron.* Vol. 21, No. 4, April, 1929.

tips consisting of rolled leaves. The spikes did not develop beyond the embryonic stage so that the culms were not at all distended by any internal growth. Special care was given this plant, for mutations of such proportions are rare in barley nurseries. We have found but three of any magnitude in 20 years. Despite the special care devoted to it, the plant did not thrive. The two culms became yellow and the plant, to all appearances, was dying. We had about given up hope of any further growth when a third culm did develop and eventually headed. Much to our surprise, it was hooded. Hooded barleys occur in progenies with certain awnless forms where the awnlessness is due in part to hooded ancestry, but here for the first time hooded barley appeared under observation from parents of purely awned constitution. Fortunately we had convinced ourselves we were dealing with a mutation before we realized it carried unusual significance. We checked all possibilities carefully. There were no hooded varieties near the F_1 in the previous season and even if there had been, crossing could not account for the appearance of such a plant. The progenies of Everest with hooded barleys always behave as any other hooded cross. The possibility of a field hybrid and a mutation occuring in the same seed are too remote mathematically to need consideration. Unfortunately the variation was sterile. Its appearance indicated that such was the case and frequent pollinations were made with no result. (See Figure 4.)

This, in brief, is the most important evidence we have found. We would have been better satisfied if the plant had not been sterile. On the other hand, if it had been fully normal, the evidence would have been less conclusive. While the mutation did not give us Nepal, it did give us a glimpse of variations of the same nature.

The origin of any form is a guess, but in summation we have these facts. Hooded barley was found in Nepal at a time when it had not spread very far east or west of that longitude. These barleys differ from the awned by a single step which is in the form of an extra floral stimulus resulting in a second floral center. In a hybrid population involving a naked awned barley from Nepal, a sterile hooded mutant appeared. Our guess is that hooded barley appeared as a mutant in a naked mountain barley of Napal or West China not more than 150 years ago.

Roman Prizes for Large Families

THE municipal government of Rome has established six prizes, to be awarded annually, over a period of five years beginning with 1932, to the largest and the healthiest families of the city. The prizes do not consist of money but of a warranty deed to a small house or apartment comprising at least four rooms and a kitchen. For the prizes may compete all parents, legally married, who, in the preceding four years, have had at least three children born to them in Rome and still living. Persons who are affected with transmissible diseases or who are addicted to alcoholism to such an extent as to impair the robustness of their offspring will be excluded from competition for the prizes. The prizes will be awarded every year on April 21, the anniversary of the natal day of Rome.

Jour. Amer. Med. Assoc. 97:1090. 1931.

A NEW MUTATION TO "DOMINANT SPOTTING" (*W*) IN THE HOUSE MOUSE

CLYDE E. KEELER

Howe Laboratory of the Harvard Medical School, and the Bussey Institution

IN the autumn of 1930 a male showing a form of variegated spotting appeared within a strain of unspotted black silver mice maintained at the Bussey Institution (see Figure 5*A*). The possibility that this variegation was due to contamination by "spotted" stocks was precluded by the fact that all pied strains in the laboratory were non-silvered, agouti or both. Either or both of these dominant characters would have appeared in the first generation resulting from any chance hybridization. Hence the new spotting must have arisen as the result of a germinal mutation which occurred somewhere in the ancestry of this particular spotted black silver male.

We have evidence that there exist in laboratory mice at least three independent genes* capable of producing spotted coat patterns: "dominant spotting" (*W*), "recessive piebald" (*s*) (see Figure 5*B*), and "all white" (*wh*). We were interested in determining whether the new mutation represented a new occurrence of one of these previously known sports or whether it was due to the mutation of one or more genes at new loci within the germ plasm.

For these reasons the mutant male was crossed to females from an inbred unspotted strain. The offspring consisted of nine unspotted and eight spotted young. Seven of the latter had merely a white blaze on the head and a small white spot on the belly. One had in addition to blaze and belly spots a general variegation resembling that of the father. These results tell us that the mutant spotting is due to the presence of a single dominant gene (*X*) which freely segregates from its normal recessive allelomorph (*x*) according to the formula

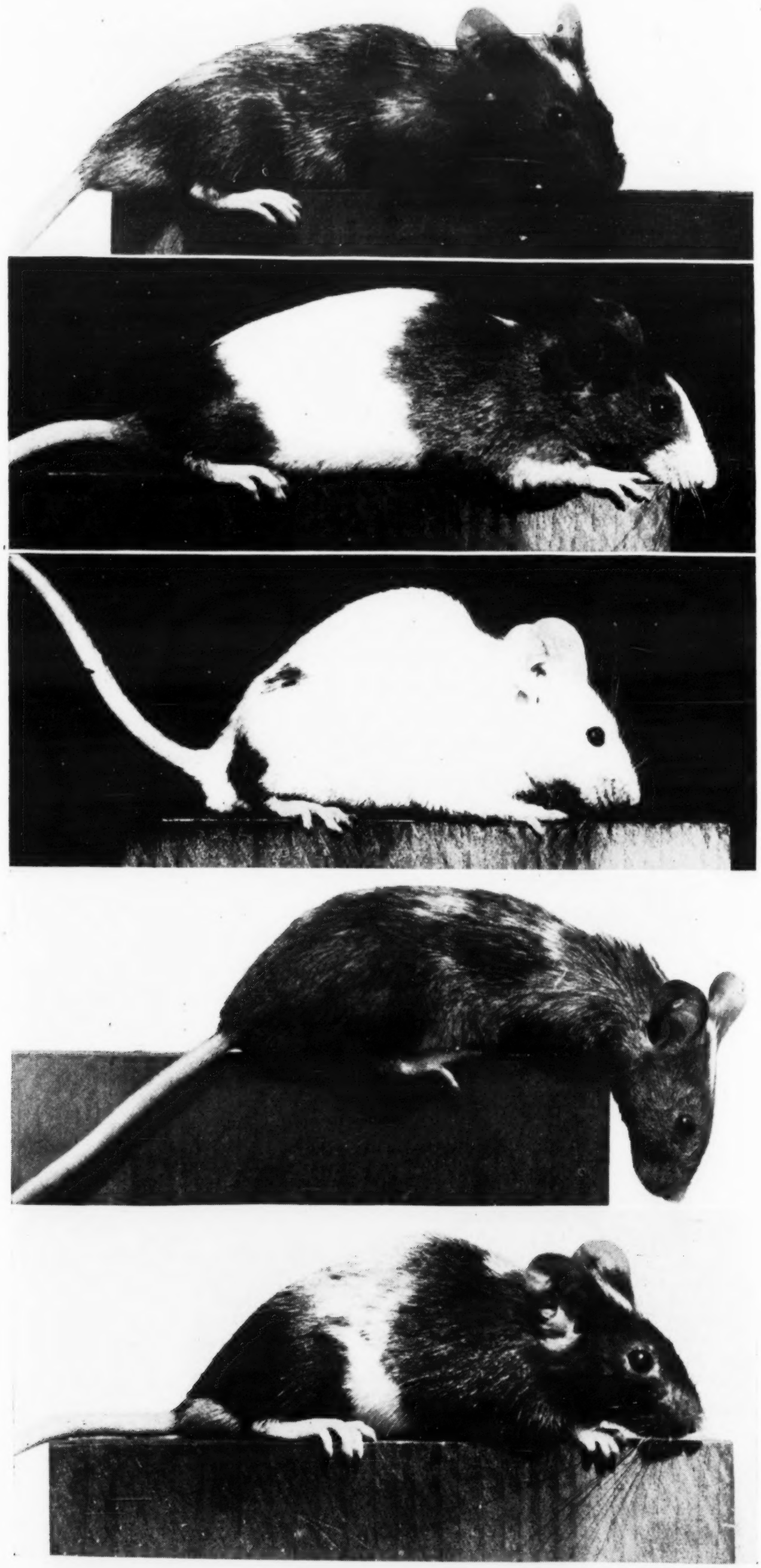
$$\underset{\text{spotted}}{Xx} \times \underset{\text{unspotted}}{xx} \rightarrow \underset{\text{spotted}}{Xx} + \underset{\text{unspotted}}{xx}$$

Upon this basis we expect the offspring containing *X* to be spotted and those bearing *x* to be unspotted. The two alternative classes should be represented in equal numbers. The numbers found, 23 spotted and 27 unspotted, closely approximate the expectation of 25 in each class.

The progenitors of the black silver strain of mice had been subjected to x-ray treatment about 5 or 6 generations previous to the one in which the mutation occurred. However, the mutation could not have been induced directly by the radiation because it would have appeared in the first generation in the first individual bearing the dominant mutant gene (*X*), and in five generations it would have marked a great number of individuals of the strain. Because of the dominant nature of the mutation we must suppose it to have occurred in a germ cell of one of the two immediate parents of the mutant mouse.

The phenotypic expression of the gene *X* (which usually produces a blaze and a belly spot, but occassionally variegation in addition) is an important clue suggesting its identity with the

*Conclusive evidence for the unrelated nature of dominant spotting and recessive piebald has already been communicated while proof for the independence of "all white" rests upon unpublished data.



A

The dominant spotting mutant (*XxSS*).

B

Recessive piebald (*wwss*).

C

Black-eyed-white spotting (*Wwss*).

D

Dominant spotting (*WwSS*) extracted from black-eyed-white.

E

Variegated mouse (*WwSs*) heterozygous for both dominant spotting and recessive piebald.

SPOTTING TYPES IN THE MOUSE

Figure 5

LETHAL FORM OF SPOTTING

Figure 6

Litter of young showing mutant dominant spotting. Two are unspotted (*wwSS*), three spotted (*WwSS*), and one is a white anemic lethal (*WWSS*).

well known "dominant spotting" gene (*W*). A common laboratory strain known as "black-eyed-white" (*Wwss*) (see Figure 5*C*) is made up of one gene for "dominant spotting" (*W*), one for its recessive allelomorph (*w*), and two genes for "recessive piebald" (*ss*), the three spotting genes combining their whitening effects to produce animals exhibiting little or no coat pigmentation but retaining black eyes. The "dominant spotting" gene (*W*) (see Figure 5*D*), when isolated from a "black-eyed-white" strain (*Wwss*) by an outcross to unspotted animals, shows identically the same coat pattern manifestations and breeding behavior as the new mutant gene *X*. But this highly suggestive similarity does not constitute conclusive proof of the identity of "dominant spotting" (*W*) with the new mutant (*X*).

It is well known that when one gene each for "dominant spotting" (*W*) and "recessive piebald" (*s*) are present in the same individual (*WwSs*) it will be spotted or high grade variegated (see Figure 5*E*). If the new mutation were really "dominant spotting" (*W*) we should expect extremely variegated and unspotted offspring in equal numbers from a cross with "recessive piebald" (*ss*) according to the following scheme:

$$WwSS \times wwss \rightarrow WwSs + wwSS$$

mutant variegated × recessive piebald → high grade variegated + unspotted

A litter of two young was produced from such a cross. One individual was high grade variegated and the other was unspotted, in agreement with expectation.

A unique characteristic of the "dominant spotting" gene (*W*) is the fact that individuals bearing the homozygous or purebred condition (*WW*) are

lethal, dying from anemia either in utero or shortly after birth has terminated their successful parasitic existence and has thrown them upon their own inadequate blood resources. The (*WW*) young are normally formed and active at birth, but pale. They are frequently too feeble to nurse. A cross producing anemic lethals may be symolized by:

$$\underset{\text{spotted}}{Ww} \times \underset{\text{spotted}}{Ww} \rightarrow \underset{\substack{\text{anemic}\\ \text{dies}}}{WW} + \underset{\text{spotted}}{2Ww} + \underset{\text{unspotted}}{ww}$$

The production of anemic lethals in the F_2 of our cross between the mutant and unspotted mice would constitute strong evidence that the new mutation *X* is identical with the *W* mutation. Failure to produce anemic lethals would lead us to suspect that we might be dealing with a new dominant mutation having a coat pattern expression similar to that of *W* or else that the lethal effect is merely linked with and not a necessary result of the *W* gene itself.

In order to test this possibility, two spotted F_1 animals were mated together. The litter which they produced (see Figure 6) was observed less than an hour subsequent to parturition. It consisted of seven perfectly formed young. Five were normal and two were anemic. One anemic was dead when found. The other lived long enough to show that it bore no coat pigmentation. Of the five normal young, three developed variegation and two produced unspotted coats. Thus the proof is complete that the dominant spotting which arose by mutation in our unspotted black silver strain is actually a new occurrence of the well known "dominant spotting" gene (*W*) found in "black-eyed-white" mice.

Summary

In an unspotted strain of mice there appeared a single individual exhibiting a variegated form of spotting. This spotting was tested genetically and found to depend for its expression upon a single dominant gene, shown by its manifestation in the coat when hybrid and its anemic lethal effect when purebred to be identical with the gene for "dominant spotting" (*W*) commonly present in "black-eyed-white" mice. These experiments indicate that the anemic lethal effect observed in *WW* animals is due to the *W* gene itself in homozygous form and not to a gene linked with it, because simultaneous mutation in the same two genes on two different occasions would be a highly improbable event.

AUTHOR'S NOTE: Since this paper went to press we have been able to syntheszie a new strain of black-eyed white mice, containing the mutant dominant spotting gene (*W*) and two recessive piebald genes (*ss*). It differs in no way from the black-eyed-white strain of the fancy.

Literature Cited

1. LITTLE, C. C. 1915. Inheritance of black-eyed-white spotting in mice. *Amer. Nat.*, vol. 49, pp. 727-740.

2. DE ABERLE, S. F. 1925. Hereditary anemia in mice, and its relation to dominant spotting. *Amer. Nat.*, vol. 59, pp. 327-335.

3. KEELER, C. E. 1931. The independence of dominant spotting and recessive spotting ("piebald") in the house mouse. *Proc. Nat. Acad. Sci.*, vol. 17, pp. 101-102.

ANTHROPOLOGY AND EUGENICS

A Review of Some Recent German Publications.

EUGENICS has found supporters among the anthropologists of most countries, the United States being no exception. In France the eugenic society not long ago gave up its independent existence to become a section of the Institut Internationale d'Anthropologie. In Italy organized eugenics began as a section of the anthropological society. The tendency to bring the two subjects close together has been equally strong in Germany, finding the most pronounced expression in Walter Scheidt's great introduction to general anthropology.[15] Other publications adopt the same point of view in their own way. And in the details of human heredity, it is probably fair to say that more research has been done in Germany than in any other country in recent years, though they also follow American work closely.[12]

Human Origins

The whole picture of the past is called up by Franz Koch's new book on human origins.[10] Starting with the evolution of the earth, and the gradual distribution of lower forms of life, he points to central or southern Europe as the region in which human characteristics began to appear during the Pliocene. The ice age drove man's ancestors out to the margins of this region, and isolation in Asia and in North Africa gave rise to distinct groups—the small negroid type of man, and the early Mediterranean type. Apart from the effects of environment in directing evolution, Dr. Koch thinks that differences in anthropoid stocks may have affected the early human racial differences. All this may have occupied a couple of million years, from the time the primeval forest in central Europe began to dry up and turn into steppe land.

Mankind then began to undergo the process of domestication, which had the same effect on him as it does on his domesticated animals,—the production of varieties. As to the exact way in which these were produced, the author is hopelessly naive. The wanderings of peoples are likewise speculative. The Nordic race is identified as the most recent of the divisions of mankind, and in common with many other recent German writers, the author attaches particular importance to it. On the whole, the book is of little scientific value, but its rich content of illustrations makes it useful.

K. Saller, in his Introduction to Anthropology, walks on firmer ground.[13] He begins with the principles (not always accurately stated) of genetics, proceeds through development, variation, and mutations, then after a section on methodology plunges into the problems of the evolution of the human species, the origin and characteristics of different races, and finally the problems of constitution, individuality, and the inheritance of differences. This work, too, is well illustrated, and while it contributes nothing new, it is a useful source of reference for much material on human heredity.

Methods

As a supplement, Dr. Saller has published a colored chart[14] showing 40 types of eye, so that students may define eye color more accurately in their reports. It should be convenient for mere anthropological surveys, but microscopic examination of human eyes has shown that all of them have traces of brown, and that simple observed categories are not enough for the study of heredity.

Statistical methods have already been adopted—in principle—by the leading anthropologists, and W. Scheidt, among others, has published a handbook.[16]

From the animal breeding industry, C. Kronacher now contributes an introduction to biometry, in a second and revised edition.[11] Though it contains a large amount of useful material in small compass, it has the defect of most such compendiums, that it does not go much beyond the product-moment coefficient of correlation. Anyone who attempts to do practical work with man soon finds the need of other procedures.

The study of blood types perhaps falls within the field of methodology as well as anywhere else. It is having a tremendous vogue, without the production of any very startling discoveries recently. Fritz Schiff has published a revised edition of his convenient handbook of methods.[17] The only exciting event in the recent history of this field was the attempt of K. H. Bauer[1] to prove that their heredity depends on two independent pairs of genes with crossing-over, rather than on the triple allelomorphs which F. Bernstein had postulated,[2] as did T. Furuhata at the same time independently, and which had been accepted by almost every geneticist. Dr. Bauer's detailed study was at once subjected to attack from all sides, and seems to be losing ground,—indeed it appears that he did not quite understand what the statistical consequences of crossing-over would be. The triple-allelomorph hypothesis may be said to hold the field at the present time, although there are plenty of indications that the inheritance of the chemical properties of the blood is extremely complex.

Sterilization

Eugenic sterilization continues to occupy a great deal of the attention of European eugenists, and Rainer Fetscher has published in the *Deutsche medizinische Wochenschrift* the answers to an inquiry which he sent to 95 cities with a population of more than 50,000 each, asking whether they were using sterilization. While there is no law providing for official sterilization in Germany, there seems to be no law against it, and a number of authorities have expressed the opinion that it can be done if a community desires.

Dr. Fetscher received no information from 19 cities. Of the remainder, 53 said they were not sterilizing, 17 were performing such operations, six would like to do so but had not felt authorized. The reports from the 17 cities mentioned covered only 112 persons, of whom 83 were women sterilized primarily on medical indications.

It is at least evident, however, that some German cities are performing eugenic sterilizations officially, and that their officials are willing to admit it.

Two detailed accounts of sterilization from the medical side have been published lately: one by the neurologist Otto Kankeleit,[9] and one by the gynecologist L. Fraenkel.[5] They contain good reviews of the literature from German sources, and useful accounts of technique, but as general studies they suffer from apparent ignorance of the only large body of evidence available on the subject (that compiled in California), although this was published in a German translation in Berlin[6] almost as soon as it appeared in popular form in New York.[7]

Popular Works

Several popular handbooks of eugenics, well illustrated, and authoritatively written, have appeared during the last few years. One of the best[3] is by Ranier Fetscher, director of the marriage counsel bureau in Dresden. Dr. Fetscher has also issued an illustrated booklet based on the exhibits of the hygiene museum in Dresden.[4] This exhibit originated in the first exposition, 1911, when Max von Gruber and Ernst Rüdin arranged a graphic display for eugenics and social hygiene, that up to the time had not been equaled, and that has rarely since been approached. It was expanded for the second exposition there, last year.

Papers of eugenic importance are widely scattered through German anthropological, medical, and psychological publications; in addition there is a growing press devoted specifically to eugenics. The latest addition to this is *Eugenik,* with the subtitle *Erblehre-Erbpflege,* which made its bow in October, 1930, in a dress that compliments the JOURNAL OF HEREDITY by close resemblance. This is a continuation (with complete change of form) of the monthly *Volksaufartung Erbkunde, Eheberatung,* which was for five years the organ of the Deutsches Bund für Volksaufartung und Erbkunde.

With this popular monthly to publish illustrated material on heredity and eugenics, the Germans also have the solid bi-monthly *Archiv für Rassen- und Gesellschafts-biologie,* which has been published since 1908 for serious contributions, and the series of papers issued somewhat irregularly from the Kaiser-Wilhelm Institut für Anthropologie, menschliche Erblehre, und Eugenik in Berlin, under the title *Das kommende Geschlecht,* with the subtitle *Zeitschrift für Eugenik: Ergebnisse der Forschung.*

"Race Hygiene" vs. "Eugenics"

In passing, it is interesting to note that the use of the words "race hygiene" as a synonym for eugenics seems to be declining in Germany. The Berliner Gesellschaft für Rassenhygiene changed its name to the Berliner Gesselschaft für Eugenik at its meeting of February 26, 1930.

This does not indicate any less interest in the problem of race, but perhaps merely a desire to avoid confusing the issues. The National Socialist Party (Hitler) which has gained some support in many German states during the last year, leans strongly toward Nordic supremacy (together with concomitant anti-Semitism), and Hans F. K. Gunther, who has for a decade been the principal exponent of the Nordic idea in Germany, was rewarded by appointment as professor of social anthropology in the University of Jena, when the party came into power in Thuringia.

The appointment was made by the Minister of the Interior against the expressed wish of the University, and caused considerable heartburning in academic circles, partly among those who do not like Dr. Günther's racial views, partly among those who felt that the university faculty should not be overridden by the government, partly by those who, through professional jealousy, disliked to see a man enter the ranks of anthropology who had started life as a specialist in literature and philology. But the appointment prevailed, and served still further to advertise the views of its beneficiary.

Dr. Günther's principal book, on the anthropology of the German people,[8] has meanwhile appeared in a 15th edition, representing many changes from the first one in 1922, and enriched by 564 illustrations and 29 maps. Whether or not one shares all the author's enthusiasm for Nordics, or can see them in all the places where he discerns their lineaments, one at least welcomes the book as the convenient source of an immense amount of useful information, particularly of a pictorial nature. The extensive appendix on the Jewish people, which as included in earlier editions, has now been removed and rebuilt into a separate book.

Starting with foundations laid half a century earlier, and made familiar by Madison Grant in the United States through his book *The Passing of the Great Race* (1916), Dr. Günther has marshalled an immense array of historical facts, together with no small number of surmises and intuitions, to illustrate the racial history of the German-speaking peoples. The volume is literary rather than scientific; one can scarcely turn to a page on which there is not some categorical statement that should be proved quantitatively, but for which no proof is offered. But with all this, the work has done a great deal to arouse an interest in eugenics, and to provoke thought as to the means

by which valuable racial elements may be conserved and perpetuated.

With a good deal of caution, Dr. Günther hazards the guess that Nordic inheritance characterizes about one-half the population of Germany. If that is correct, it is probable that the United States is somewhat more Nordic in its composition than is Germany. A study on this point would be of great interest.

Literature Cited

1. Bauer, K. H. "Zur lösung des Problems der Blutgruppenvererbung." Klinische Wochenschrift 7(34):(1-12). Aug. 19, 1928. Published more fully as "Zur Genetik der menschlichen Blutgruppen." *Zeitschrift f. induktive Abstammungs und Vererbungslehre* 50(1):3-62. 1929.
2. Bernstein, F. Zusammenfassende Betrachtungen über die erblichen Blutstrukturen des Menschen. *Zeitschrift f. induktive Abstammungs- u. Vererbungslehre* 37(3):237-270. 1925.
3. Fetscher, R. Abriss der Erbbiologie und Eugenik. 155 p. 79 illus. Berlin, Verlag Otto Alle, 1927.
4. Fetscher, R. Grundzűge der Eugenik, 2d ed. Deutsches Hygiene-Museum, Leben und Gesundheit, Band 4. 80 p. 36 illus. Deutsche Verlag für Volkswohl fahrt, Dresden, 1929.
5. Fraenkel L. Sterilisierung und Konzeptionsverhütung." *Archiv f. Gynäkologie* 144(1):86-132. 1930.
6. Gosney, E. S., and Paul Popenoe. Sterilisierung zum Zweck der Aufbesserung des Menschengeschlechts. Trans. by Konrad Burchardi. Abhandlungen aus dem Gebiete der Sexualforschung, Band 5, Heft 5. 78 p. Berlin and Kőln, A. Marcus and E. Weber's Verlag, 1930.
7. Gosney, E. S. and Paul Popenoe, Sterilization for Human Betterment. N. Y., the Macmillan Co., 1929.
8. Gunther, Hans F. K. Rassenkunde des deutschen Volkes. 15th ed. 509 p. 564 illus. 29 maps. M.14. J. F. Lehmanns Verlag, Munich, 1930.
9. Kankeleit, Otto. Die Unfruchtbarmachung aus rassenhygienischen und sozialen Grűnden. 112 p. 7 illus. M.7. J. F. Lehmanns Verlag, Munich, 1929.
10. Koch, Franz. Ursprung und Verbreitung des Menschengeschlechts. 174 p. 66 illus. Gustav Fischer, Jena. 1929.
11. Kronacher, C. and C. von Patow. Biometrik, eine Einfűhrung. 71 p. M.6.50. Berlin, Paul Parey, 1930.
12. Popenoe, Paul. Des kindes Erbschaft. (Trans. of The Child's Heredity, by Felix Tietze.) Deutsche Verlag, Stuttgart, 1930.
13. Saller, K. Leitfaden der Anthropologie. 284 p. 128 illus. Price M.25.80. Berlin, Julius Springer, 1930.
14. Saller, K. Augenfarbentafel, in linen cover M.10. Springer, Berlin, 1930.
15. Scheidt, Walter. Allgemeine Rassenkunde. 585 p. 165 fig. J. F. Lehmanns Verlag, Munich, 1925.
16. Scheidt, Walter. Rassenforschung. 82 p. 12 illus. George Thieme Verlag, Leipzig, 1927.
17. Schiff, Fritz. Die Technik der Blutgruppenuntersuchung. 92 p. 32 illus. M.8.60. Berlin, Julius Springer, 1929.

Paul Popenoe

A Biological Prospectus

BIOLOGY IN HUMAN AFFAIRS, *edited by* E. M. East. Pp. xi+399. Price, $3.50. Whittlesey House, McGraw Hill Co., N. Y. 1931.

EVERY now and then publishers of scientific books prevail upon some authority (who has been successful in attracting the public to his specialty) to present an all star cast in a somewhat wider field. In this way the canny publishers are able to take advantage of the "good will" created by the editor in his own right as well as to capitalize on the impressive list of the contributing stars.

Biology in Human Affairs is such a book. Edited by Professor East and numbering among its authors such men as Jastrow, Terman, Fishbein and McCollum the public has every reason to expect a worthwhile production. Instead the purchaser is certain to feel he has been hoodwinked into spending his good money for a biological "sales talk."

As a matter of fact, multiple authors, retaining their identity by chapters, almost never produce a readable book though just why this should be is not clear since the whole should equal the sum of its parts. However that may be, this form of literary cooperation

seems suited best for works of an encyclopedic nature. Several of the contributors to the present volume have demonstrated elsewhere an ability to present instructive material in an engaging manner but their combined efforts here are disappointing. Perhaps the unsatisfactory nature of the book is due to a reluctance on the part of the editor to wield the blue pencil on his distinguished confrères.

Whatever the cause *Biology in Human Affairs* can not be classified as a book but rather as a collection of loosely-related essays. Even viewed from this standpoint there are needless repetitions that are certain to annoy the nature reader to whom the work is addressed.

Although Professor East believes the biologist "has much to offer both to man the intelligent being and to man the animal, subject to hunger and disease," the present treatise can be described only as an appeal to man the animal.

In it the reader is told just what biologists are doing for his bodily welfare or if they are not doing it just now they will be doing it in the future! No picture has been presented of the biologist at work but rather an effort has been made to catalog the biological discoveries that have direct economic value.

There is no gainsaying that biology has made innumerable contributions to human welfare but the temptation inherent in the viewpoint of applied biology has not been avoided and in consequence the book is, if not intellectually dishonest, at least intellectually misleading. A wholly false idea is conveyed of the motives that actuate biologists and what is even more unfortunate, their discoveries are warped into economic applications. Herein lies the book's failure. It reads like an appeal to budget authorities for additional funds and as such it would be excellent. Unquestionably biology needs and deserves financial aid but books of this nature are likely to alienate the intelligent sources of money without attracting the support of the small tax payer.

Biology in Human Affairs divides roughly into three sections; Sociology and Psychology; Heredity, Medicine, Physiology and Zoology; and Food and Diet. In all there are twelve essays of which Professor East contributes two—the introduction and one on heredity. With these the reader will find no fault and they clearly excel all the others. Professor East not only expresses himself lucidly but he has as well a trenchant style just suited to discomforting those venturesome celebreties who stray from the rigorous scientific thinking of their restricted fields into the misty regions of metaphysical speculation.

Of the other essays Professor Jastrow's "The Renaissance of Psychology" easily takes second rank. His contribution is essentially the story of psychology restricted of course, by space limitations.

The reviewer can seen no reason for including "The Prospects of the Social Sciences" or "The Outlook of Public Health Work." Both are in the nature of special pleading and while public health work is all applied biology the social sciences have vet to benefit by biological progress. The essay on "Psychology in Industry" is simply the trade recommending itself to big business with an ironclad guarantee of certain profits.

The most disappointing contributions are those of Doctor Fishbein and Professor Parshley which is all the more remarkable since both of these men are artists in popularizing their respective sciences. Doctor Fishbein fails here in his presentation by attempting too much—modern progress in the entire field of medicine in 42 pages while Professor Parshley's thunder was stolen by almost all the other authors, leaving him little to do but make a direct appeal for funds. Perhaps his essay should have appeared last as a sort of summary and raison d'être for the volume.

In the chapter on food increase Doctor Jones propagates some errors such as having potatoes in cultivation in North America before the discovery, and in having the Irish prosper after the chemical control of the Phytopthora disease of potatoes, and in having maize originate in Central America. However, these questions are important only to the specialist. To the general reader this essay will engender the idea that biological science has made present day agriculture possible which unfortunately is far from the case. Our present agricultural development has resulted almost entirely from rule of thumb methods and superstition and the benefits agriculture may derive from modern biology belong to the realm of future possibilities.

There is much of interest packed into this volume but one feels that a much better book (in the sense of balance and style) would have resulted had Professor East written the entire thing himself. As it is it can not compare with *Essays in Popular Science,* by Julian Huxley, which covers somewhat the same ground without, however, attempting to prove economic applications. Professor Huxley, in his essay on the frog, produced a masterpiece and one which should serve as the standard for all future authors in this field. *Biology in Human Affairs* does not offer the reader anything nearly so worthwhile. J. H. KEMPTON.

Books Received

BOOKS are acknowledged in this column as received, and such acknowledgment must be regarded as sufficient return for the courtesy of the sender. As far as space permits, books that contain material of special interest to the readers of the JOURNAL *will be reviewed in later numbers.*

AN HYPOTHESIS OF POPULATION GROWTH, *by* EZRA BOWEN, PH. D., Head of the Department of Economics of Lafayette College. Pp. 238. 15 Chapters. Price, $3.75. New York, Columbia University Press. 1931.

A billion-and-a-half of us now—How ***did*** we get that way? Almost as complicated as the problem of the origin of life, apparently.

LE PROBLEME DE L'EVOLUTION, *by* MAURICE CAULLERY. Pp. 447. Paris, Payot. 1931.

Another of these problems.

BY WORD OF MOUTH, Informal Essays on Language and Psychology from a Teacher's Point of View, *by* TATIANA W. BOLYDYREFF, M. A. Pp. 144. 8 Chapters. Price, $2.00. Boston, Richard G. Badger, The Gorham Press. 1931.

Fortunately genes aren't transmitted that way.

THE ADVENTURE OF MANKIND, *by* EUGEN GEORG. Translated from the German by Robert Bek-Gran. Pp. 325. 2 Parts, 7 Chapters. New York, E. P. Dutton & Co. 1931.

Just fiction. The moon finally falls in when there doesn't seem to be any other way to stop that increase that bothers Bowen et al, and then the survivors have it all to do over again. Quite worth reading.

MEXICO, A Study of Two Americas, *by* STUART CHASE, in collaboration with MARIAN TYLER. Illustrated by Diego Rivera. Pp. 338. 15 Chapters. Price, $3.00. New York, The Macmillan Co. 1931.

A *very interesting* look south of the Rio Grande, in the inimitable Chase style.

THE HORSE OF THE DESERT, *by* WILLIAM ROBINSON BROWN, with an introduction by Major General James G. Harbord and Henry Fairfield Osborn, D. Sc., LL. D., Ph. D. Pp. 218. 7 Chapters. 156 Illustrations. Price, Regular Edition, $27.50; De Luxe Edition, $100.00. New York, The Derrydale Press. 1928.

The Arabian horse done in style befitting so noble an animal.

COSMIC CONSCIOUSNESS, A Study in the Evolution of the Human Mind, *by* RICHARD MAURICE BUCKE, M. D., Formerly Medical Superintendent of the Asylum for the Insane, London, Canada. Pp. 384. 6 Parts. Price, $5.00. New York, E. P. Dutton & Co. 1931 (First Edition, 1901).

Another trip to the Inward See. If genes were catching an environmental or inspirational explanation would be easy. Since they are not, there must be a reason why some become cosmically conscious and some do not. Genes perhaps.

THE INHERITANCE OF BODY WEIGHT IN THE DOMESTIC FOWL

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ALTHOUGH the nature of the inheritance of a relatively large number of characters in the domestic fowl has been determined during recent years, but little progress has been made in determining the number of factors involved in the inheritance of body weight in any class of poultry. This is natural because few investigations have been made concerning such a complex problem as the inheritance of body weight, involving as it does, several factors including differences in the weights of mature males and females of most breeds of poultry. Since the inheritance of many characters, such as color, feather structure and other morphological characters, has been determined to be Mendelian in nature, it is interesting to determine whether or not body weight is also inherited in a Mendelian manner.

Ghigi[1] crossed Paduan fowls of Italy and bantams and observed that the F_1 progeny were intermediate in weight between the parental breeds and that later generations showed no tendency to vary greatly from the F_1 progeny. Few individuals were raised, however, so that no conclusions could be drawn regarding the number of factors involved.

Goldschmidt[2] crossed Pekin ducks with wild Mallard drakes and obtained an F_2 progeny that showed considerable variation in weight among the few individuals raised.

Phillips[6, 7] crossed French Rouen ducks with domestic Mallard drakes and secured 70 F_1 progeny and 64 F_2 progeny. The F_2 males were much more variable in size than the F_2 females. It was observed that the F_2 males showed considerably greater variability in body weight than the F_1 males but that the F_2 females showed only a slightly increased variability in body weight than the F_1 females.

Punnett and Bailey[9] crossed Golden Penciled Hamburg males with Silver Sebright bantam females and obtained an F_2 progeny of 233 birds, 112 males ranging in weight from 680 to 1,420 grams each and 121 females ranging in weight from 540 to 1,290 grams each, the weights being recorded at 35 weeks of age. It was observed that for each sex of the F_2 progeny "the range of variation is such that the smallest birds are smaller than the Silver Sebright bantam, while the largest are larger than the Golden Hamburg." The problem was studied further by mating together one family of the largest of the F_2 progeny as well as by mating together each of two families of the smallest of the F_2 progeny. The family of the large-sized F_2 birds produced F_3 birds of relatively large size, although there was considerable variation. The families of small-sized F_2 birds produced relatively small-sized F_3 birds, the family of smallest F_2 birds producing no F_3 progeny that weighed over 600 grams. The authors observed that "These F_3 results taken together suggest strongly that size in poultry depends upon definite factors, and that these factors segregate in gametogenesis."

May[5] crossed White Cornish and Silver Spangled Hamburgs, data being obtained at 10 months of age from reciprocal crosses of the two breeds. The F_1 and F_2 progeny weighed on the

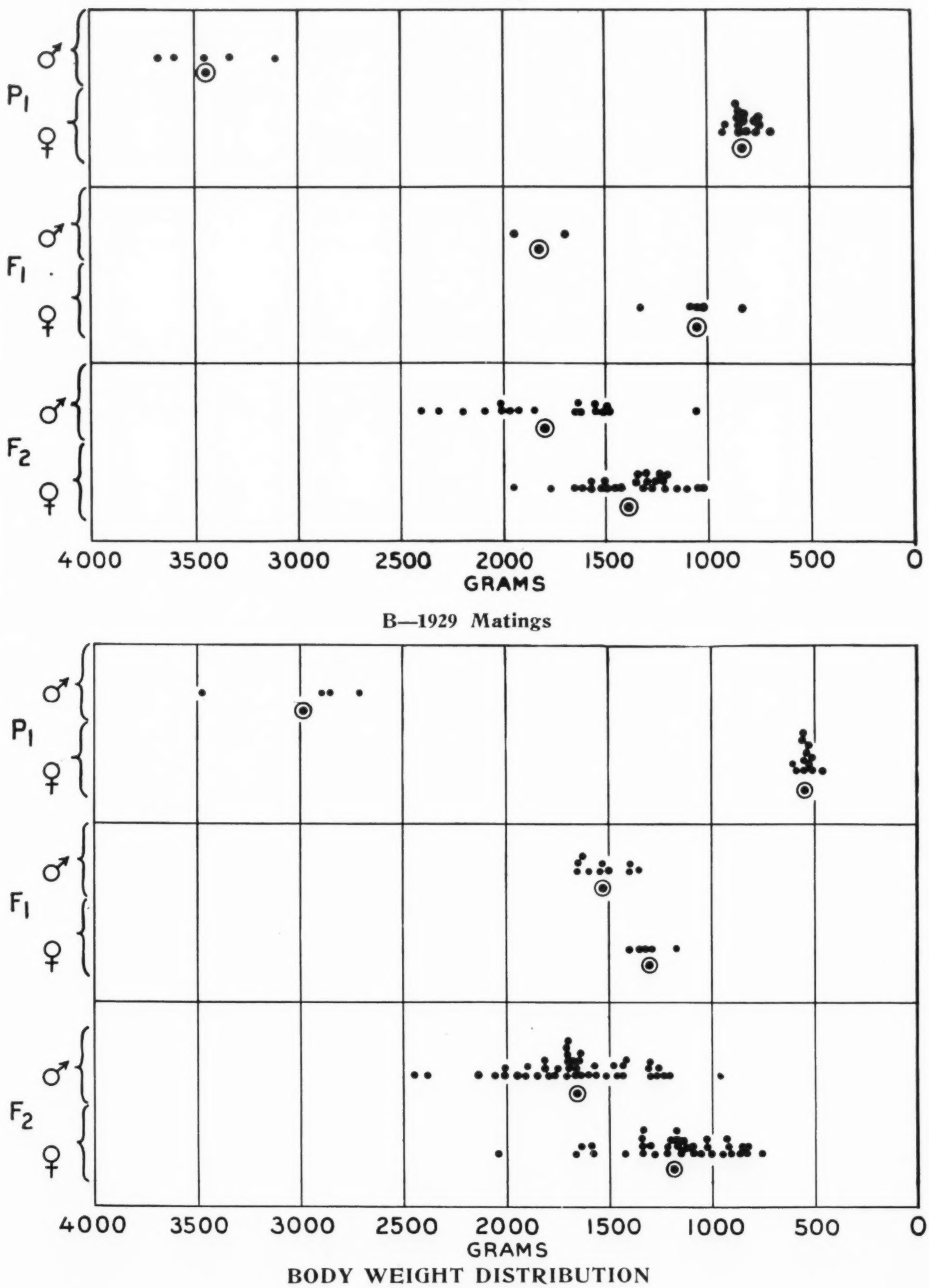
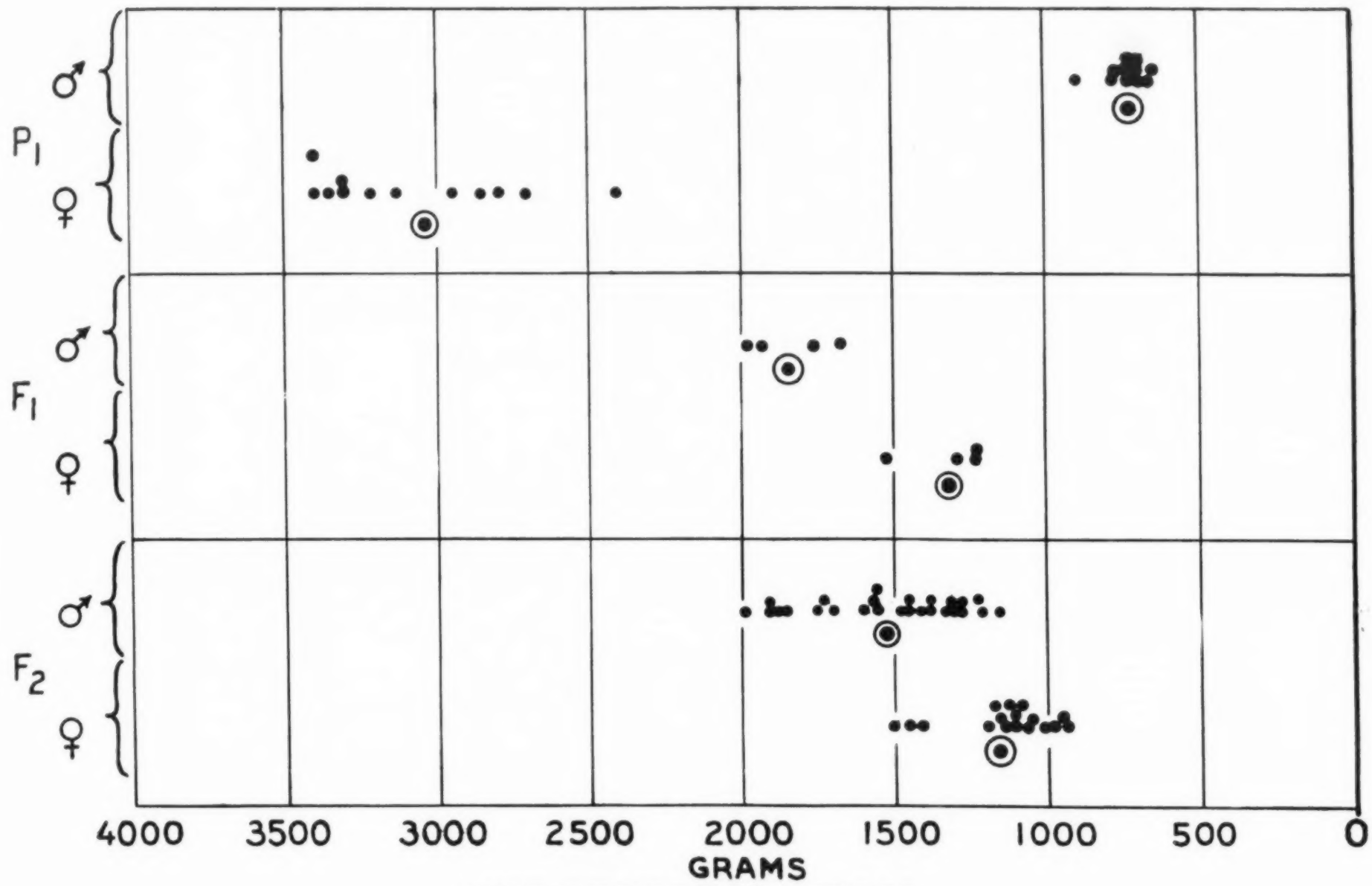


Figure 7

The distribution of body weights in the parental, F_1 and F_2 generations, respectively, in the 1928 and 1929 mating of Barred Plymouth Rock males mated to Rose-Comb Black Bantam females.



THE RECIPROCAL CROSS

Figure 8

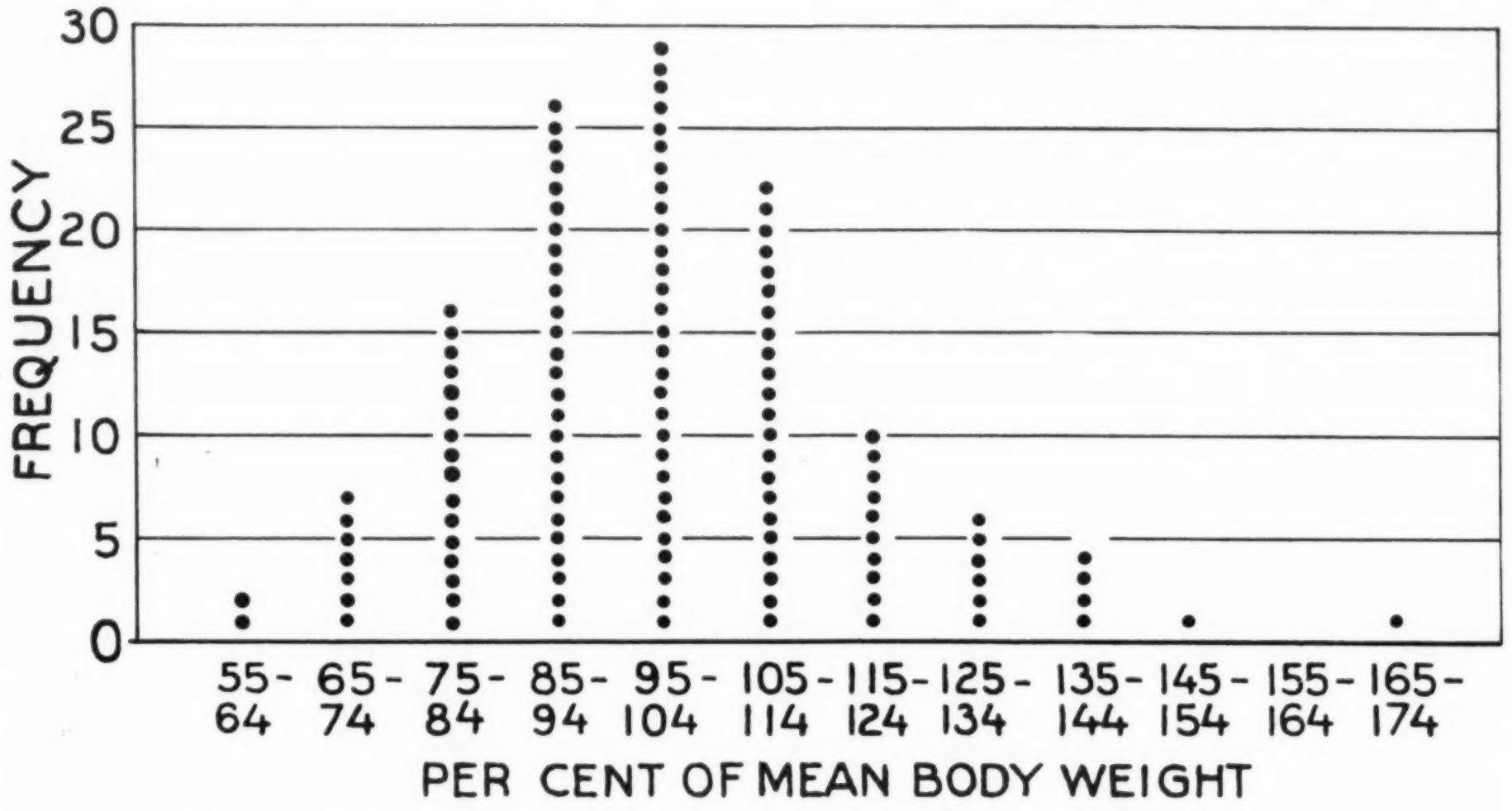
The distribution of body weights in the parental, F_1 and F_2 generations, respectively, in the 1929 mating between Rose-comb Black Bantam males and Barred Plymouth Rock females.

average almost as much as the average weights of the Cornish according to sex. Moreover, the F_1 and F_2 progeny were not any more variable in weight than the purebred parental stocks. The number of birds in the F_2 families, however, was quite small, 21 males and 28 females being secured from the cross of Silver Spangled Hamburg males and Cornish females, 4 males and females each from the reciprocal cross of Cornish males and Silver Spangled Hamburg females and 14 males and 17 females from F_1 males out of an original mating of Cornish males and Silver Spangled Hamburg females mated to F_1 females out of an original mating of Silver Spangled Hamburg males mated to Cornish females. The number of F_2 progeny is too small to allow of any deductions being drawn regarding the number of factors involved in the inheritance of body weight.

Kopec[4] made reciprocal crosses between White Leghorns and Buff Orpingtons and studied the inheritance of body form as well as body weight. Concerning the inheritance of body weight, it was observed that the F_1 females from the mating of Buff Orpington males and White Leghorn females weighed more than the F_1 females from the mating of White Leghorn males and Orpington females. In the case of the mating of Buff Orpington males and White Leghorn females the F_2 females weighed considerably more than the F_1 females, although in the case of both F_2 males and females there was greater variability than in the case of the F_1 males and females, respectively. Kopec found that in both the F_1 and the F_2 progeny not a single bird resembled either the Leghorn or the Orpington in body build.

Crossing Barred Plymouth Rocks and Rose-Comb Black Bantams

Additional data on the inheritance of body weight in the domestic fowl are available from reciprocal crosses



BODY WEIGHT DISTRIBUTION IN THE SECOND GENERATION

Figure 9

The frequency distribution of individual body weights expressed as percentages of the mean body weight of the males and females, respectively, in the F_2 of the 1928 and 1929 matings, respectively, between Barred Plymouth Rock males and Rose-Comb Black Bantam females.

recently made between Barred Plymouth Rocks and Rose-Comb Black Bantams. These crosses were made at the U. S. Animal Husbandry Experiment Farm, Beltsville, Maryland, the first cross being made in 1928 and subsequent matings in 1929 and 1930.

Owing to the great difference in size between the Plymouth Rocks and the bantams artificial insemination was practiced. Barred Plymouth Rock males were allowed to mate with Rhode Island Red females and immediately after mating took place the semen was extracted from the cloaca of the females and injected into Rose-Comb Black Bantam females. For the other cross, Rose-Comb Black Bantam males were allowed to mate with Rose-Comb White Bantam females and the semen was immediately extracted and injected into Barred Plymouth Rock females. Artificial insemination of the Rose-Comb Bantam females proved to be much more successful than that of the Barred Plymouth Rock females.

The F_1 and the F_2 progeny were weighed each year when the birds were approximately 30 weeks of age.

Barred Plymouth Rock Males Mated to Rose-Comb Black Bantam Females

In 1928 there were 5 Barred Plymouth Rock males varying from 3,115 to 3,680 grams each and averaging 3,434.00 grams mated to 15 Rose-Comb Black Bantam females ranging from 690 to 950 grams each and averaging 826.00 grams. From this mating there were produced 7 F_1 birds, 2 males weighing 1,680 and 1,960 grams, respectively, and 5 females weighing 1,310, 1,085, 1,065, 1,035 and 835 grams, respectively. In 1929 the F_1 male weighing 1,680 grams was mated to the 5 F_1 females and this mating produced an F_2 progeny of 18 males and 26 females. The males ranged in weight from 1,065 to 2,400 grams with an average of 1,803.61 $\pm$ 54.39 grams. The females ranged in weight from 1,020 to 1,950 grams with an average

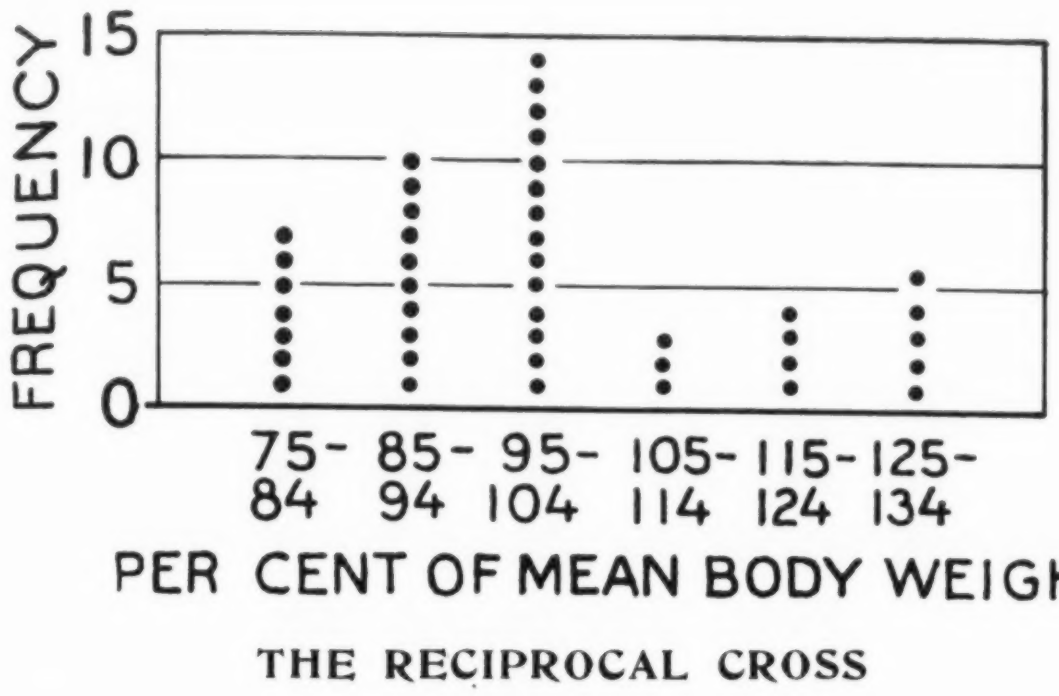


Figure 10

The frequency distribution of individual body weights expressed as percentages of the mean body weight of the F_2 males and females, respectively, in the 1929 mating between Rose-Comb Black Bantam males and Barred Plymouth Rock females.

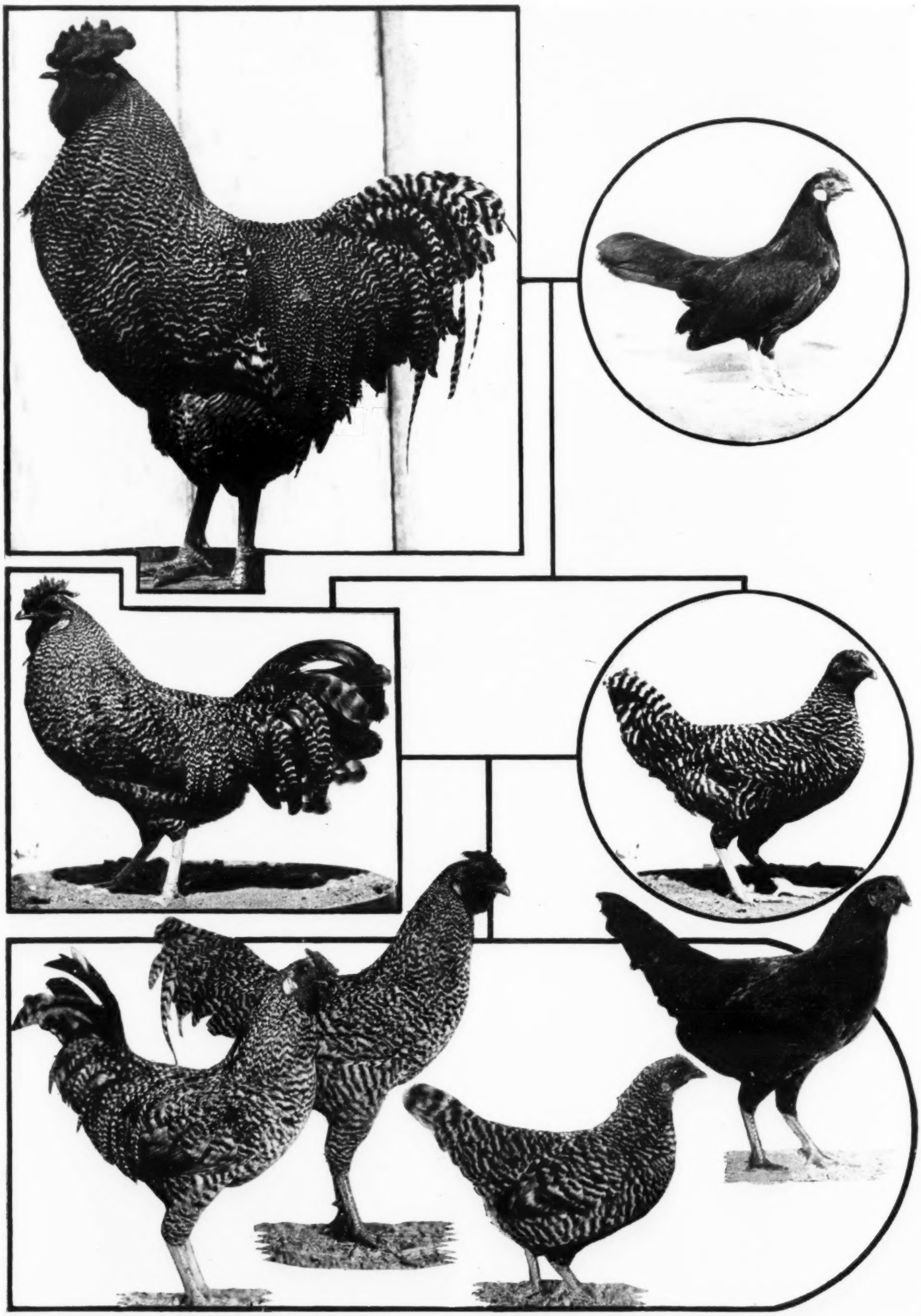
of 1,382.50 ± 29.82 grams. The difference between the mean weight of the males and of the females is 421.11 ± 62.03 grams.

In 1929 another mating was made between 4 Barred Plymouth Rock males, varying from 2,718 to 3,488 grams each and averaging 2989.80 grams, and 12 Rose-Comb Black Bantam females varying from 465 to 580 grams each and averaging 545.83 grams. Both males and females were considerably smaller than the males and females used in the original cross in 1928. The F_1 progeny produced by the second original mating includes 10 males, ranging in weight from 1,340 to 1,650 grams and averaging 1,527.00 grams and 5 females ranging in weight from 1,170 to 1,396 grams each and averaging 1,305.00 grams. These 5 females and 4 F_1 females from the 1928 original cross were mated in 1930 to an F_1 male of the 1929 original cross. The male weighed 1,505 grams and the 9 females averaged 1,223.33 grams. This F_1 mating produced in 1930 an F_2 progeny of 44 males, ranging in weight from 965 to 2,440 grams, averaging 1,659.50 ± 30.48 grams and 36 females ranging in weight from 765 to 2,040 grams, averaging 1,185.83 ± 30.95 grams. The difference in weight between the F_2 males and females is 473.67 ± 43.44 grams.

It is observed that there is considerable range in variability of body weight in the F_2 progeny secured from the original cross made in 1928 as well as in the F_2 progeny secured from the original cross made in 1929. In both sexes, however, the mean weights of the F_2 progeny from the 1928 matings are somewhat greater than the mean weights of the F_2 progeny from the 1929 matings. The difference is probably due to the fact that larger birds in both of the parental breeds were mated together in 1928 than in 1929, although some difference may have resulted from the fact that the two F_2 families were raised in different years.

Rose-Comb Black Bantam Males Mated to Barred Plymouth Rock Females

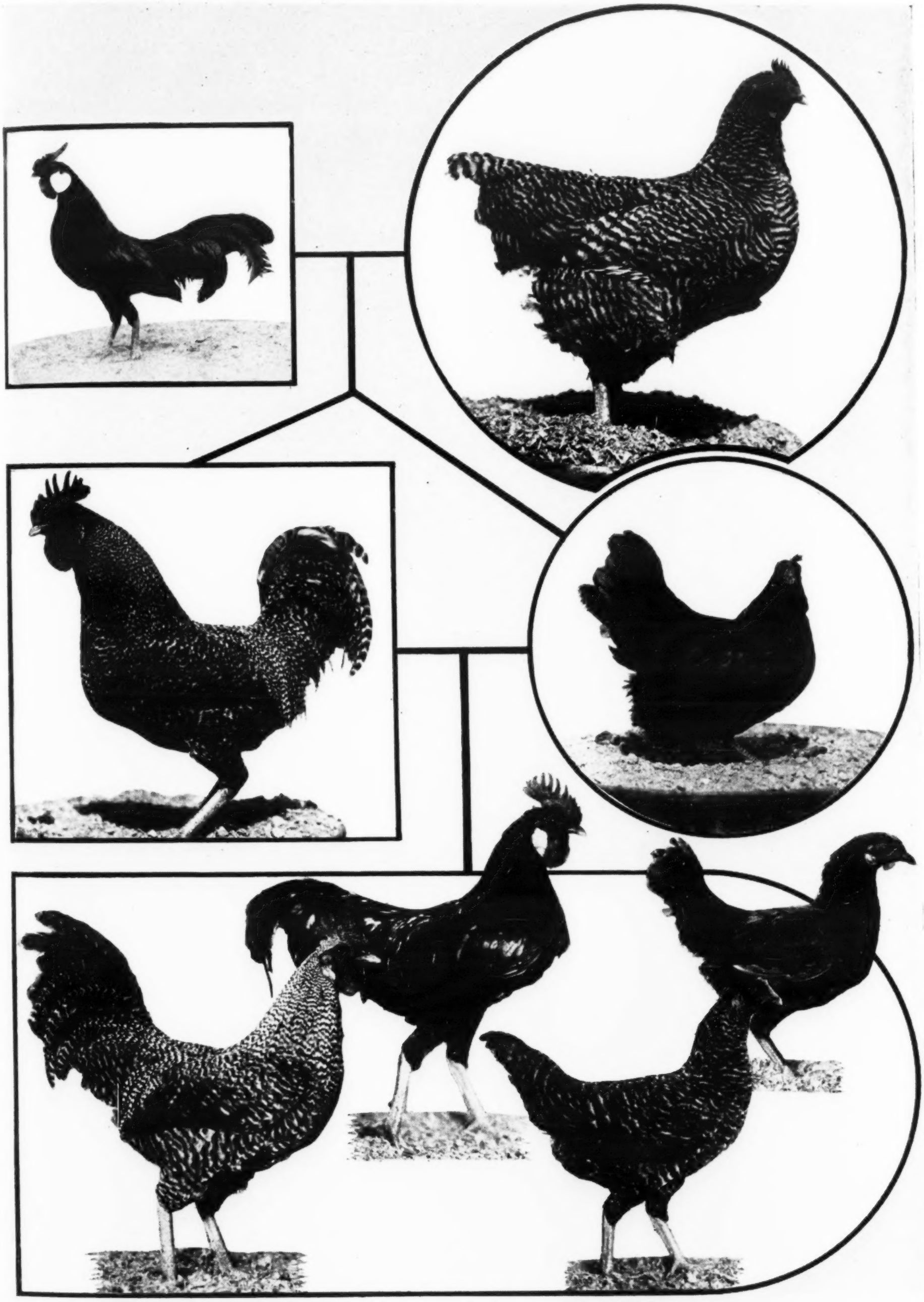
In 1928 matings were made between Rose-Comb Black Bantam males and Barred Rock females but the fertility was extremely low and only one pullet was raised to maturity. In 1929 other matings were made between 11 males varying from 640 to 895 grams each and averaging 729.09 grams and 11 females varying from 2,401 to 3,397 grams each and averaging 3,037.98 grams. The F_1 progeny comprised 4 males averaging 1,833.45 grams and 4 females averaging 1,323.45 grams. An F_1 male weighing 1,755 grams was mated to the 4 F_1 females and an F_2 progeny was produced comprising 26 males, ranging in weight from 1,160 grams to 1,990 grams, averaging 1,527.69 ± 32.76 grams, and 17 females ranging in weight from 930 grams to 1,500 grams, averaging



A PLYMOUTH ROCK-BANTAM CROSS

Figure 11

Photographs of three generations of fowls actually used and produced in the crosses discussed in this article. The F_1 is intermediate in size, and in the F_2 neither of the extremes of parental body-weight were obtained, indicating that several factors are involved. Note that color behaves in this cross in typical Mendelian fashion—barring being dominant. The barring factor is sex-linked, as is indicated by the absence of barred males in the F_2, and by the "criss-cross inheritance" in the reciprocal cross (See Figure 12).



THE RECIPROCAL CROSS

Figure 12

In this cross the size-factors behaved about as in the reciprocal cross. The color factors show typical sex-linked mendelian inheritance, F_1 females being black and males barred, and in F_2 half of each sex being of either color. Before definite conclusions can be reached with regard to the inheritance of body weight, more uniform strains of the parental breeds must be obtained by inbreeding, and a much larger F_2 must be raised.

1,140.00 ± 27.88 grams. The difference in weight between the F_2 males and the F_2 females is 387.69 ± 43.02.

The mean weights of the sires, dams, and male and female F_1 and F_2 progeny, respectively, for the three different matings are shown in Table I.

Interpretation of the Results

It is to be observed first that the original crosses made in this experiment involve breeds that differ more widely in body weight than in the case of any other crosses made in studies on the inheritance of body weight in the domestic fowl. Punnett and Bailey[4] state that in the case of their crosses the Silver Sebright bantams weighed a little more than one-half as much as the Golden Penciled Hamburgs. May[5] states the Silver Spangled Hamburgs in his crosses weighed approximately two-thirds as much as the Cornish. In the case of this experiment the Barred Plymouth Rocks weighed approximately from four and one-half to over five times as much as the Rose-Comb Black Bantams.

If the inheritance of body weight is Mendelian in nature it is reasonable to suppose that the more widely the two breeds that are crossed differ in body weight the greater the number of factors involved in the inheritance of body weight and consequently the greater the segregation in body weight in the F_2 progeny. Figures 8 and 9 show respectively the mean body weights and the distribution of individual body weights of the parents and the F_1 and F_2 progeny in the 1928 and 1929 Barred Plymouth Rock males × Rose-Comb Black Bantam female matings and in the 1929 Rose-Comb Black Bantam male × Barred Plymouth Rock female matings.

In the case of all three matings the mean weight of the males and the females in the F_1 progeny is much nearer the mean weight of the bantam parents than the mean weight of the Barred Plymouth Rock parents. This suggests the partial dominance of one or more factors for small size although Punnett (1923) observes in connection with the experiment by Bailey and himself that the same collection of weight factors on a Silver Sebright Bantam frame and on a Hamburg frame might produce birds of different weights. To whatever extent this is true then it becomes necessary to study the inheritance of body shape in crosses differing in body shape and it also becomes necessary to study the influence of body shape on body weight.

The results secured in this experiment, however, are contrary to those secured by Punnett and Bailey[9] and by May[5] both of whom found that the F_1 generation approached the larger-sized parent in body weight more than the smaller-sized parent. In fact, May observed that there were no significant differences between the mean body weights of the Cornish parents and the F_1 progeny in the reciprocal crosses between Cornish and Silver Spangled Hamburg, although in the case of both sexes the data show that the F_1 progeny from the mating of Cornish male and Silver Spangled Hamburg female was somewhat heavier than the F_1 progeny of the mating of Silver Hamburg male and Cornish female. In a cross between Jersey Black Giants and White Leghorns, Warren[10] observed that the F_1 progeny more nearly approached the size of the Jersey Black Giant parents, the larger of the two breeds.

The F_1 progeny in all three matings in this experiment show considerable variability, a result to be expected bearing in mind the fact that the parental breeds exhibited considerable variability, a fact true of practically all breeds of poultry. The F_1 progeny in the crosses made by Punnett and Bailey and by May also showed considerable variability, May stating that in the case of his Cornish × Silver Spangled Hamburg matings the F_1 generation showed about the same

amount of variability as his parental stocks.

The F_2 generation in the case of May's experiments showed about the same amount of variability as his F_1 progeny and his parental stocks. Punnett and Bailey, however, found that the F_2 birds showed greater variability in body weight than the F_1 birds and that among the F_2 birds there was some that were smaller than the Silver Sebright Bantams and others larger than the Golden Penciled Hamburgs. It is unfortunate that Punnett and Bailey apparently did not consider the amount of variability in the parental Silver Sebright and Golden Penciled Hamburg stocks from which they selected the two Silver Sebright females and the one Golden Penciled Hamburg male used in the original mating. It is known for instance that the Silver Sebrights normally show considerable variability in body weight and it is altogether probable that Golden Penciled Hamburgs show no less variability than Barred Plymouth Rocks, Cornish and Rose-Comb Black Bantams.

At the same time, the results secured by Punnett and Bailey and those secured in this experiment are in agreement in respect to the greater amount of variability in body weight among the F_2 progeny than among the F_1 progeny. On the other hand, although Punnett and Bailey secured some F_2 birds larger than the Golden Penciled Hamburg male and smaller than the Silver Sebright Bantam females used in their original cross, none of the F_2 birds in the case of all three crosses in this experiment were as large as the smallest of the Barred Plymouth Rocks or as small as the largest of the Rose-Comb Black Bantams used in the original crosses. The difference in the two experiments may be accounted for by the fact that Punnett and Bailey secured a larger F_2 generation than in the case of this experiment, the larger the number of factors involved in the inheritance of body weight the greater the number of progeny required in order to secure the extremes in body weight among the F_2 progeny.

In order to determine the amount of segregation in the F_2 progeny of the mating of the Barred Plymouth Rock males and Rose-Comb Black Bantam females, the results of the 1928 and 1929 original crosses are considered together. Since the mean body weight of the males differs significantly from the mean body weight of the females in the case of each mating, as shown previously, and since the mean body weight of the males and females from the 1928 mating differ, respectively, from the mean body weight of the males and females from the 1929 mating, apparently the only way of combining the body weights of all of the F_2 male and female progeny from both matings is to determine for each bird its body weight as a percentage of the mean body weight of the males and females, respectively, for each of the matings. The frequency distribution of the birds classified on this basis of determination is shown in Table II and Figure 9.

The same procedure has been followed with respect to the F_2 male and female progeny of the 1929 mating of Rose-Comb Black Bantam males and Barred Plymouth Rock females, the data being given in Table III and Figure 10.

The data in Table II and Figure 9 show that among the F_2 progeny of Barred Plymouth Rock males mated with Rose-Comb Black Bantam females there is a wider range in the distribution of body weights than among the F_2 progeny of Rose-Comb Black Bantam males mated with Barred Plymouth Rock females, as shown in Table III and Figure 10. Whether the difference is due to the smaller numbers in the case of the latter cross or to differences in the amount of variability in the parental stocks of the two crosses is impossible to say.

The frequency distribution of the P_1 body weights expressed as percentages of the mean body weight of the male and female parents, respectively, for each of the two crosses, is shown in Table IV together with the frequency distribution of the F_2 body weights expressed as percentages of the mean body weight of the F_2 males and females, respectively, for each of the two crosses. In this way it is possible to compare the relative amount of variability among the male and female parents and their F_2 progeny in each of the two crosses.

The greater variability of the F_2 progeny of the cross of Barred Plymouth Rock males and Rose-Comb Black Bantam females as compared with the variability of the F_2 progeny of the reciprocal cross may be due to the relatively greater variability of the female parents of the first as compared with the second cross, as shown in Table IV.

Summary

The results of the three matings involving the reciprocal crosses reported in this experiment are not only in agreement in showing relatively less variability of body weight in the F_1 progeny than in the F_2 progeny but also in respect to the fact that the variability of body weight in the F_2 progeny does not include birds as large as the smallest of the Barred Plymouth Rock parents nor as small as the largest of the Rose-Comb Bantam parents. If four independently segregating factors are involved in the inheritance of body weight in the domestic fowl, as Punnett[8] has suggested, it would be expected that some of the extremes in body weight would be produced in an F_2 population of 124 individuals, as secured in one cross in this experiment, although 256 individuals are necessary in order to secure the appearance of all possible combinations of weight characters. None of the extremes were produced in the F_2 progeny, however, and the nature of the frequency distribution of the F_2 progeny on the basis of body-weight percentages of the mean suggest that probably more than four factors are involved. Indeed, many factors may be involved.

Kopec[4] observes that the body dimensions of the domestic fowl are inherited in part independently of each other. He believes that there are genes that affect the size of the body as a whole but that there are also genes that independently determine the size of various parts of the body.

This suggestion is in accord with the observations of Hutt[3] in connection with his investigation concerning sex dimorphisom and variability in the appendicular skeleton of the Leghorn, his observation being "that while there are genetic size factors affecting all parts of the body, there must also be special factors affecting only certain regions and certain individual bones."

The relative size of the F_1 progeny in the reciprocal crosses suggests that there is dominance or partial dominance of one or more factors associated with the inheritance of body weight in Rose-Comb Black Bantams over the factors associated with the inheritance of body weight in Barred Plymouth Rocks.

It is felt that the results of this experiment do not show that body weight in the domestic fowl is inherited in Mendelian manner and it is apparent that in order to secure conclusive evidence on the matter large F_2 families should be raised from original crosses of highly inbred strains, the individuals of which are as uniform as possible in respect to body weight.

Literature Cited

1. Ghigi, Alessandro, 1909. Richerche di sistematica sperimentali sul genere Gennæus wagler. Bologna, p. 38.

2. Goldschmidt, R., 1913. Zuchtversuche mit Enten. *Zeit, fur Induct. Abstammungs und Vererbungslehre.* Bd. 9, p. 161.

3. Hutt, F. B., 1929. Sex dimorphism and variability in the appendicular skeleton

of the Leghorn fowl. *Poul. Sci.* 8: pp. 202-218.

4. KOPEC, STEFAN, 1927. Zur Kenntnis der Vererbung der Körperdimensionen und der Körperform beim Houshuhn. *Zeitschrift fur induktive abstammungs und Vererbungs=lehre* Bd. XLV Heft pp. 87-104.

5. MAY, HENRY G., 1925. The inheritance of body-weight in poultry. I. In The Cornish-Hamburg cross. *R. I. Agr. Exp. Sta. Bull.* 200, pp. 1-34.

6. PHILLIPS, J. C., 1911. Inheritance of size in ducks. *Jour. Exp. Zool.* 12, pp. 369-380.

7. ————, 1914. A further study of size inheritance in ducks with observations on the sex ratio of hybrid birds. *Jour. Exp. Zool.*, 16, pp. 131-148.

8. PUNNETT, R. C., 1923. Heredity in Poultry. pp. 1-204. Published by Macmillan & Co., New York.

9. ————, and BAILEY P. G., 1914. On inheritance of weight in poultry. *Jour. Genetics*, 4, pp. 23-29.

10. WARREN, D. C., 1926. Genetics of breed characteristics. *Poul. Sci.* 5: pp. 209-212.

TABLE I—The mean body weights in grams of the sires, dams, F_1 males, F_1 females, F_2 males and F_2 females, respectively, in the 1928 and 1929 matings of Barred Plymouth Rock males mated to Rose-Comb Black Bantam females and the 1929 mating of Rose Comb Black Bantam males mated to Barred Plymouth Rock females.

	Barred Plymouth Rock ♂♂ × Rose-Comb Black Bantam ♀♀		Barred Plymouth Rock ♀♀ × Rose-Comb Black Bantam ♂♂
	1928	1929	1929
Sires	3,434.00	2,989.80	729.09
Dams	826.00	545.00	3,037.98
F_1 ♂♂	1 820.00	1,527.00	1,833.45
F_1 ♀♀	1,066.00	*{1,305.00} {1,223.33}	1,323.45
F_2 ♂♂	1,803.61±54.39	1,659.50±30.48	1,527.69±32.76
F_2 ♀♀	1,382.50±29.82	1,185.83±30.95	1,140.00±27.88

*1,305.00 is the mean body weight of the F_1 ♀♀ produced from the 1929 mating whereas 1223.33 is the mean body weight of the F_1 ♀♀ produced from both 1928 and 1929 matings and used to produce the F_2 progeny in the 1929 mating.

TABLE II—The frequency distribution of the F_2 progeny of the 1928 and 1929 matings of Barred Plymouth Rock males and Rose-Comb Black Bantam females on the basis of indiviual body weights expressed as percentages of the mean body weight of the males and females, respectively, for each mating.

Per cent of mean body weight	1928 Mating Males	Females	Total	1929 Mating Males	Females	Total	Grand Total
55-64	1		1	1		1	2
65-74		1	1	1	5	6	7
75-84	3	3	6	6	4	10	16
85-94	5	7	12	8	6	14	26
95-104	1	5	6	13	10	23	29
105-114	4	6	10	7	5	12	22
115-124	2	2	4	5	1	6	10
125-134	2	1	3	1	2	3	6
135-144		1	1	1	2	3	4
145-154				1		1	1
155-164							
165-174					1	1	1
Total	18	26	44	44	36	80	124

TABLE III—The frequency distribution of the F_2 progeny of the 1929 mating of Rose-Comb Black Bantam males and Barred Plymouth Rock females on the basis of individual body weights expressed as percentages of the mean body weight of the males and females, respectively.

Per cent of mean body weight	Males	Females	Total
75-84	5	2	7
85-94	6	4	10
95-104	6	8	14
105-114	3		3
115-124	3	1	4
125-134	3	2	5
Total	26	17	43

TABLE IV—The frequency distribution of the male and female parents, respectively, and the F_2 progeny of each of the reciprocal crosses between Barred Plymouth Rocks and Rose-Comb Black Bantams, on the basis of individual body weights expressed as percentages of the mean body weight of the males and females, respectively, for each cross.

Per cent of mean body weight	Barred Plymouth Rock ♂ ♂ × Rose-Comb Black Bantam ♀ ♀			Ross-Comb Black Bantam ♂ ♂ × Barred Playmouth Rock ♀ ♀		
	♂ parents	♀ parents	F_2 progeny	♂ parents	♀ parents	F_2 progeny
55-64			2			
65-74		4	7			
75-84	1	7	16		1	7
85-94	2	1	26	3	3	10
95-104	2	1	29	6	2	14
105-114	4	4	22	1	4	3
115-124		8	10	1	1	4
125-134		1	6			5
135-144		1	4			
145-154			1			
155-164			0			
165-174			1			
Total	9	27	124	11	11	43

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